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FORM PTO-1390 (REV 11-2000) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY 'S DOCKET NUMBER: 298-149

U S APPLICATION NO (If known, see 37 CFR 1 5): 10/019637

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/EP00/05953	27 JUNE 2000	30 JUNE 1999

TITLE OF INVENTION: METHOD AND DEVICE FOR PYROLYZING AND GASIFYING ORGANIC SUBSTANCES OR SUBSTANCE MIXTURES

APPLICANT(S) FOR DO/EO/US: WOLFGANG KRUM, GUNTER FUNK AND STEFAN HAMEL

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [X] This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. [X] The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [ ] is attached hereto (required only if not communicated by the International Bureau).
   b. [X] has been communicated by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [X] An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. [X] is attached hereto. (12 pgs. Specification, 5 pgs Claims, 2 pgs Abstract)
   b. [ ] has been previously submitted under 35 U.S.C. 154(d)(4).
7. [X] Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are attached hereto (required only if not communicated by the International Bureau).
   b. [ ] have been communicated by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [X] have not been made and will not be made.
8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. [ ] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. [X] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [X] A FIRST preliminary amendment.
14. [ ] A SECOND or SUBSEQUENT preliminary amendment.
15. [ ] A substitute specification.
16. [ ] A change of power of attorney and/or address letter.
17. [ ] A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. [ ] A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. [ ] A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. [X] Other items or information: 3 sheets of formal drawings; Form PCT/IB/308

CERTIFICATION UNDER 37 C F R § 1 10

I hereby certify that this correspondence and the documents referred to as enclosed are being deposited with the United States Postal Service on date below in an envelope as "Express Mail Post Office to Addressee" Mail Label Number _EV035533481US_ addressed to Assistant Commissioner for Patents, Box PCT, Washington, D C 20231

Dated: 12/28/01

GEORGE M. KAPLAN

531 Rec'd PCT/PTO 28 DEC 2001

U.S APPLICATION NO (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
10/019637	PCT/EP00/05953	298-149

21. ☒ The following fees are submitted:	CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1040.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$890.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$740.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$710.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ $890.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	20 - 20 =	0	x **$18.00**	$	
Independent claims	2 - 3 =	0	x **$84.00**	$	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$280.00**	$	
TOTAL OF ABOVE CALCULATIONS =				$ $890.00	
☒ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.			+	$ -$445.00	
SUBTOTAL =				$ $445.00	
Processing fee of **$130.00** for furnishing the English translation later than ☒ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				$	
TOTAL NATIONAL FEE =				$ $445.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$	
TOTAL FEES ENCLOSED =				$ $445.00	
				Amount to be refunded:	$
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a. ☒ A check in the amount of $ $445.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. 04-1121 in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 04-1121 . A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s): Krum et al. Examiner:

Serial No.: Not yet assigned Group Art Unit:

Filed: herewith Docket: 298-149

For: METHOD AND DEVICE FOR PYROLYZING AND GASIFYING ORGANIC... Dated: November 28, 2001

Assistant Commissioner for Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT

Sir:

Please enter the following Preliminary Amendment in the above-identified application:

IN THE SPECIFICATION:

Page 1, between lines 4 and 5 (underneath the title) insert - -BACKGROUND OF THE INVENTION- -;

Change page 4, lines 1-3 to read as follows:

- -SUMMARY OF THE INVENTION

These objects are solved by the features set forth herein. Advantageous embodiments and further developments of the invention result with the use of the features set forth herein.- -;

CERTIFICATION UNDER 37 C.F.R. § 1.10

I hereby certify that this correspondence and the documents referred to as enclosed are being deposited with the United States Postal Service on date below in an envelope as "Express Mail Post Office to Addressee" Mail Label Number **EV035533481US** addressed to: Assistant Commissioner for Patents, Box PCT, P.O. Box 2327, Arlington, Va 22202.

Dated: November 28, 2001

George M. Kaplan

Page 7, between lines 10 and 11 insert - -BRIEF DESCRIPTION OF THE DRAWINGS- -- -; and

between lines 20 and 21 insert - -DESCRIPTION OF THE PREFERRED EMBODIMENTS- -.

IN THE ABSTRACT:

Insert the abstract found upon the accompanying pages in its entirety.

IN THE CLAIMS:

Amend Claims 3-11 and 13-15 as follows and add Claims 16-20:

3. A method in accordance with claim 1, wherein the product gas (23) is guided back in the pyrolysis reactor (1).

4. A method in accordance with claim 1, wherein solidifying agents (21) such as steam, oxygen or air or a mixture thereof are added into the pyrolysis reactor (1).

5. A method in accordance with claim 1, wherein the surface of the reactor wall of the combustion fluidized bed (3) has any closed geometrical shape on the side of the pyrolysis reactor (1) and the combustion fluidized bed (3).

6. A method in accordance with claim 1, wherein the reactions of the pyrolysis gases (13) with the solidifying agent (21) are carried out at temperatures of 800°C to 1,050°C.

7. A method in accordance with claim 1, wherein the reactions of the pyrolysis gases (13) with the solidifying agent (21) are carried out in the presence of a catalyst.

8. A method in accordance with claim 1, wherein the reactions (13) with the solidifying agent (21) are carried out in a solid bed of catalyst material.

9. A method in accordance with claim 1, wherein the reactions of the pyrolysis gases (13) with the solidifying agent (21) are carried out in a fluidized bed of catalyst material.

10. A method in accordance with claim 1, wherein the reactions of the pyrolysis gases (13) with the solidifying agent (21) are supplied in the presence of a catalyst added to the pyrolysis gas (13) in the entrained flow.

11. An apparatus for the carrying out of a method for the pyrolysis and gasification of organic substances or mixtures of organic substances, comprising a pyrolysis reactor (1), a fluidized-bed firing (3) for the pyrolysis residue, a reaction zone (2) for the pyrolysis gases (13), and a fluidized-bed material circulation between the combustion fluidized bed (3) and the pyrolysis reactor (1),

characterized in that

a shaft reactor or a rotary reactor having a sluice for the application material and an inlet for the fluidized-bed material from the combustion fluidized bed (3) is disposed next to the combustion fluidized bed;

the shaft reactor (1) has a transport apparatus into the combustion fluidized bed at its lower end;

the combustion fluidized bed (3) has an overflow for transferring the fluidized-bed material into the shaft reactor (1); and

the waste gases (37) of the combustion fluidized bed (3) can be supplied to a heat transfer member (2) which is connected to the shaft reactor (1) for the pyrolysis gases (13).

13. An apparatus in accordance with claim 11, wherein fluidized-bed material can be removed from the combustion fluidized bed (3) at least at one point or at a plurality of points by means of one or more overflows and can be guided into the pyrolysis reactor.

14. An apparatus in accordance with claim 10, wherein refractory substances can be added to form a fluidized bed.

15. An apparatus in accordance with claim 10, wherein the components of the application material which cannot be burned and which cannot be gasified can be used in form of a fluidized bed.

16. An apparatus in accordance with claim 12, wherein fluidized-bed material can be removed from the combustion fluidized bed (3) at least at one point or at a plurality of points by means of one or more overflows and can be guided into the pyrolysis reactor.

17. An apparatus in accordance with claim 12, wherein refractory substances can be added to form a fluidized bed.

18. An apparatus in accordance with claim 13, wherein refractory substances can be added to form a fluidized bed.

19. An apparatus in accordance with claim 12, wherein the components of the application material which cannot be burned and which cannot be gasified can be used in form of a fluidized bed.

20. An apparatus in accordance with claim 13, wherein the components of the application material which cannot be burned and which cannot be gasified can be used in form of a fluidized bed.

REMARKS:

The claims in the application are 1-20.

Favorable consideration of the application as amended is respectfully requested.

The claims have been amended to eliminate all multiple dependencies with Claims 16-20 being added. The specification has been amended for formal reasons with the abstract formally inserted (a marked-up copy is enclosed).

Early favorable action is earnestly solicited.

Respectfully submitted,

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A method and an apparatus for the pyrolysis and gasification of organic substances or mixtures of organic substances

The invention relates to a method for the pyrolysis and gasification of organic substances or mixtures of organic substances and to an apparatus for carrying out such a method.

A series of methods are known for the treatment and utilisation of organic substances and mixtures of organic substances by, for example, gasification and pyrolysis. The methods differ according to the oxidation or reduction gas used and according to the type of contact between the solid and the gas. In solid bearing or gas bearing a distinction is made between, among others, a circulating fluidised-bed gasifier, an entrained-bed gasifier, a rotary furnace gasifier and a moving-bed gasifier with counterflow gas bearing, co-current gas bearing or cross-flow gas bearing. The majority of known gasification methods is not suitable for smaller, decentralised systems due to the high apparatus effort. Smaller, decentralised systems are advisable in particular when biomass is used as the application material.

The operating behaviour of gasification methods in accordance with the principle of the circulating fluidised bed is highly dependent on the respective particle size household of the fluidised bed consisting of the application material to be gasified and the also circulating inert material. Corresponding demands result from this on the unit size of the application material. Extremely higher demands on the preparation of the fuel result in the case of entrained-bed gasification which only allows the use of pulverised fuel particles.

Further substantial disadvantages of the known gasification methods are that the proceeding process stages of drying, degassing, gasification and incineration of the application material proceed in zones which are directly next to one another and which merge into one another. As a result, the individual zones within a reactor are undefined and the degassing, gasification and incineration can proceed incompletely at points. In further known methods, an attempt is made to eliminate these disadvantages by the separation of the individual process stages proceeding at the fuel of degassing, gasification and incineration.

In DE 197 20 331 A1, a method and an apparatus for the gasification or incineration of dry or damp, fine-particle or fragmentary biomass and of waste are proposed in which due to the hot walls of an incinerator and due to the inflow of hot waste gas from the incinerator into a degassing furnace, biological raw materials degas in this, whereby coke and pyrolysis gas are produced, with the coke arriving at the glow bed of the gasification reactor after passing the shredder, whereas the pyrolysis gas burns in the incineration chamber of the gasification reactor under the supply of a limited amount of air and the waste gas produced subsequently flows through the glow bed of the gasification reactor in which an oxidation of the carbon to CO takes place with a simultaneous reduction of waste gas (CO_2) and steam (H_2O) to a combustible lean gas (CO, H_2). Due to the fact that the pyrolysis is carried out due to the heating because of the contact with hot combustion waste gases and that furthermore a partial incineration of the pyrolysis gas is carried out, only a product gas with a low calorific

value can be produced with the method proposed in DE 197 20 331 A1. When fuels with a high content of volatile components and a low pyrolysis coke yield are used, there is a risk of an insufficient formation of the glow bed of the gasification reactor consisting of pyrolysis coke, whereby the oxidation of the carbon to CO with a simultaneous reduction of waste gas and steam to a combustible lean gas proceeds insufficiently at the cost of the product gas calorific value.

A method is furthermore known from US 4,568,362 for the gasification of organic substances and mixtures of organic substances in which the organic substances are led into a pyrolysis reactor in which the organic substances come into contact with a heat transfer medium, whereby a rapid pyrolysis takes place which transforms the organic substances into pyrolysis products which consist of pyrolysis gases with condensable substances and a solid carbonaceous residue and the required heating energy for the pyrolysis is produced by incinerating the solid carbonaceous residue in a combustion reactor and in a second reaction zone of the pyrolysis reactor, the pyrolysis gases containing tar are subjected to such crack reactions and reactions with steam that a product gas with a high calorific value is obtained. In these methods, both the pyrolysis and the incineration of the solid carbonaceous residue take place in a fluidised bed. A reaction zone for the pyrolysis gases containing tar is provided in the upper part of the pyrolysis fluidised bed. The operation of the fluidised beds requires a high effort and a control of the reactions of the pyrolysis gases in the reaction zone is hardly possible.

The German patent application 197 77 693.0 of older priority and not pre-published, on which the German patent DE 197 55 693 C1 has been granted, discloses a method for the gasification of organic substances and mixtures of organic substances.

It is the underlying object of the invention to provide a method which is simple to carry out for the pyrolysis and gasification of organic substances or mixtures of organic substances and an apparatus to generate a gas with a high calorific value.

These objects are solved by the features of claims 1 and 11. Advantageous embodiments and further developments of the invention result with the use of the features set forth in the dependent claims.

In a method for the pyrolysis and gasification of organic substances or mixtures of organic substances, this object is solved in accordance with the invention in that the pyrolysis is carried out in a moving-bed reactor or a rotary reactor, that a solidifying agent, for example steam and/or oxygen, is optionally added to the pyrolysis gases and that they are led into a reaction zone in which the pyrolysis gases react with the solidifying agent. The solid carbonaceous residue and, optionally, a portion of the pyrolysis gas are led to a fluidised-bed combustion reactor on their own or together with the fluidised-bed material and incinerated there. The fluidised-bed material is heated up there. The combustion waste gases and the fluidised-bed material are brought into contact with the reaction zone such that their thermal content can be used for the reaction of the pyrolysis gases with the solidifying agent. Fluidised-bed material taken from the fluidised-bed combustion reactor and consisting of ash, unburned coke and, optionally, additionally supplied refractory fluidised-bed material, is returned to the pyrolysis reactor as a heat transfer medium, with the heat transfer to the application material for the carrying out of the pyrolysis taking place by contact with the fluidised-bed material and, optionally, additionally through the hot wall of the fluidised-bed combustion reactor.

The hot fluidised-bed material supplied to the pyrolysis reactor from the combustion fluidised bed effects a fast drying and pyrolysis of the application material by contact. A shaft furnace is suitable as the reactor, with the mixture of the application material and the fluidised-bed material migrating from the top to the bottom through the shaft furnace. In order to ensure the solid transport through the shaft furnace, fixed equipment, conveyor spirals or agitators can be provided in accordance with the prior art. The pyrolysis reactor can, for example, also be designed as a rotary reactor, whereby a good mixing of the application material and the hot fluidised-bed material

is achieved and, at the same time, the solid transport is achieved. The steam which escaped from the application material during drying and the pyrolysis gases leave the pyrolysis reactor and enter into a further reaction zone. The mixture of the remaining solid carbonaceous pyrolysis residue and the fluidised-bed material is conveyed together into the combustion fluidised-bed, with conventional components such as screw conveyors or star wheels with inclined tube carrying-in being able to be used. A screw is preferred in the apparatus of the invention.

Due to the fact that the pyrolysis is preferably carried out in a shaft oven, the supply of a fluidising medium required for a pyrolysis fluidised-bed can be omitted. In this way, the possibility exists to carry out the pyrolysis completely without supplying gas or, unlike a pyrolysis fluidised bed to which a minimum amount of gas must be supplied for fluidising, to add any desired low amounts, for example of the product gas or of a solidifying agent such as steam, oxygen or air. In this way, the possibility exists to add gas or a solidifying agent to the pyrolysis reactor as a technical method adaptation to the respective application material. In the method of the invention, the pyrolysis is preferably carried out in the pyrolysis reactor in the absence of air and of gas. Another advantage of the carrying out of the pyrolysis in a separate process stage consists of the crushing effect which occurs during pyrolysis allowing the use of coarser fragmentary material than normally used in fluidised-bed reactors due to the smouldering and degassing. Alternatively, the possibility exists of interposing a crushing apparatus such as a roller crusher before the carrying-in apparatus for the solid carbonaceous pyrolysis residue and the fluidised-bed material into the combustion fluidised bed, whereby the demands on the application material particle sizes can be further reduced. The energy to be used for the crushing of pyrolysis coke is here substantially lower than that for the crushing of, for example, biomass such as wood.

The carbonaceous solid pyrolysis residue is incinerated with air in the fluidised bed, itself thereby becomes fluidised-bed material as ash and, due to the energy release,

further heats up or again heats up fluidised-bed material already present. The combustion fluidised bed can be designed and operated according to the level of knowledge of fluidised bed technology. A stepped addition of air can be advantageous with respect to the emissions of the combustion fluidised bed. The combustion reactor is designed as a stationary fluidised bed, that is the gas amount of the fluidised medium must be sufficient, on the one hand, to exceed the minimum fluidisation rate of the solid and must not, on the other hand, exceed the speed for the yield. From a fluidised bed height of approximately 2.5 m to 3 m, fixed equipment is required to prevent the formation of a pulsing fluidised bed and the accompanying pressure pulsations. The fluidised-bed material heated up by the combustion procedure is finally again supplied to the pyrolysis reactor. The fluidised-bed material consists of the ash which remains from the incineration of the solid carbonaceous residue. If an incomplete combustion of the pyrolysis coke within the combustion fluidised bed takes place, the fluidised-bed material which is guided in the circuit as the heat transfer medium consists of the ash of the application material and of unburned carbonaceous pyrolysis residue. As the solid carbonaceous residues of the organic substances and mixtures of organic substances as a rule transform rapidly in the combustion fluidised bed and in part can only have low portions of material which cannot be gasified or incinerated, it is optionally necessary to add additional material in order to form a fluidised bed. Additional material does not need to be added if the application materials have large amounts of material which cannot be gasified or incinerated, which are suitable to build up a fluidised bed. All refractory materials such as sand with a grain diameter of less than 1.5 mm are suitable as the material to be added which serves to form a fluidised bed. The removal of the hot fluidised-bed material and the transport into the pyrolysis reactor is preferably effected by means of one or more overflows which are provided at the reactor wall or project through the reactor wall into the fluidised bed. The method has the advantage that, in addition to the transfer of the hot fluidised-bed material into the pyrolysis reactor, the fluidised bed height of the combustion fluidised bed can be set in a simple manner. The removal of the fluidised-bed material can also be carried out by means of other known

conveyors such as a screw conveyor; however in this case the technical method effort is higher.

The invention is based on the basic idea of structuring the method into process stages which are simple to carry out. The individual process stages are their interplay can accordingly be ideally designed while taking into account the special properties of the application material and with respect to the intended product gas quality to be achieved.

Further advantages of the invention are shown by the drawings described in the following in which preferred embodiments of the invention are shown by way of example. The drawing shows

Fig. 1 the mass flows and energy flows of the pyrolysis stage, of the reaction zone and of the combustion fluidised bed of the method in accordance with the invention;

Fig. 2 an embodiment of the method in accordance with the invention in a schematic representation; and

Fig. 3 an embodiment of the apparatus in accordance with the invention in a schematic representation.

It can be seen from Fig. 1 that the application material 10 and the fluidised-bed material 35 are supplied as the heat transfer medium into the pyrolysis stage 1. The heat flow transported with the fluidised-bed material 35 results from the temperature of the combustion fluidised bed, from the condition and the mass flow of the fluidised-bed material 35 and of the application material flow 10 and from the desired pyrolysis temperature. Furthermore, a solidifying agent 11 is supplied and a heat flow 34 transferred from the combustion fluidised bed 3. There exits from the pyrolysis

stage 1 pyrolysis gas 13 which is guided into the reaction zone 2, pyrolysis gas 15 which is guided into the combustion reactor (to the combustion fluidised bed 3), a mixture of fluidised bed material and solid carbonaceous pyrolysis residue 14 and a heat loss flow 12.

The mixture of fluidised-bed material and solid carbonaceous pyrolysis residue 14 is guided into the combustion fluidised bed 3 together with pyrolysis gas 15 and air 31. The fluidised-bed material 35 heated up by the incineration is guided back into the pyrolysis reactor 1. The also hot waste gas 37 exits the combustion fluidised bed 3. A portion of the heat 36 contained in the waste gas is transferred to the reaction zone 2. There furthermore exits the combustion reactor 3 a heat loss flow 33 and fluidised-bed material 32 which has to be removed in order to regulate the overall solid household in stationary operation.

The pyrolysis gas 13 supplied to the reaction zone 2 is transformed together with the solidifying agent 21 into the product gas 23 with the aid of the supplied heat 36 in the presence of a catalyst. The product gas 23 and a heat loss flow 22 finally exit the reaction zone 2.

Embodiment

In the following example, the preferred design of the method of the invention and of the apparatus of the invention is described. The preferred method in accordance with Fig. 2 and the preferred apparatus in accordance with Fig. 3 serves for the pyrolysis and gasification of 900 kg of wood per hour. The wood used as an example substantially consists of 52.3 percent by weight of carbon, 5.9 percent by weight of hydrogen and 41.8 percent by weight of oxygen, in each case with respect to the fuel substance free of water and ash, and furthermore has an ash portion of 0.51 percent by weight with respect to the raw application material. The calorific value of the wood

amounts to H_u = 17.2 MJ/kg with respect to the state free of water; the thermal gasifier power thus amounts to 3.92 MW.

In the preferred embodiment described in Figure 2 of the method for wood gasification, wood 10 is subjected to crushing and/or drying in a preparation stage 4 depending on the condition of the application material before it is passed into the pyrolysis stage 1. The wood has a water content of 8.9 percent by weight after the preparation stage 4.

The pyrolysis is carried out at a temperature of 580°C. The fluidised-bed material 35 introduced into the pyrolysis reactor 1 has a temperature of 900°C so that the 4.1-fold amount of fluidised-bed material, that is 3.7t/h, has to be supplied and be in circulation in order to heat up the application material to the pyrolysis temperature of 580°C. On the pyrolysis of the wood, there finally remains 20.3 percent by weight (with respect to the fuel, raw) as the solid pyrolysis residue which has a calorific value of H_u = 30 MJ/kg. The remaining products from the drying and pyrolysis leave the pyrolysis reactor 1 as the gas 13 and enter into the reaction zone 2. The mixture of solid pyrolysis residue and fluidised-bed material 14 is supplied to the combustion fluidised bed 3 and burned there with air 31. The enthalpy flow supplied to the combustion fluidised bed with the solid pyrolysis residue of the wood amounts to 1.52 MW. In the present example, a power excess coupled to the flue gas flow 37 remains in the combustion fluidised-bed material 3 after removal of the heat loss 33, of the removed fluidised-bed material 32, of the fluidised-bed material 35 and of the energy amount 36 transferred to the reaction zone 2. For this reason, a superheated steam flow is generated with a water flow 70 subjected to treatment 7 while taking into account the firing efficiency in the heat transmission member 8. If the steam flow 21, which is supplied to the reaction zone 2, is taken from the superheated steam flow generated in 8, a superheated steam flow 71 remains with a power of 0.45 MW which is stress relieved via a turbine 9.

Under the supply of the solidifying agent of steam 21, the pyrolysis gases 13 are led into the reaction zone 2 consisting of a heat transmission member which is fitted with a catalyst to improve the tar cracking. The energy required for the reaction of the pyrolysis gas 13 with the steam 21 is emitted to the heat transfer element 2 via the hot flue gas flow 36 from the combustion fluidised bed 3, with the reaction taking place at 850°C to 900°C depending on the operation management of the combustion fluidised bed 3. Air or oxygen can also be mixed to the solidifying agent of steam 21 for a further temperature increase by a partial incineration of the pyrolysis gas. The product gas 23 obtained has a calorific value of 9.87 $MJ/M^3(V_N)$ and is made up of the following gas components: 48.7 percent by volume H_2; 36.1 percent by volume CO, 0.1 percent by volume CH_4; 6.1 percent by volume CO_2; 9 percent by volume H_2O. The product gas 23 is subsequently dust-separated and quenched in a preparation stage 5. The cold gas efficiency, that is the chemical energy of the application material with respect to the chemical energy content of the product gas, amounts to 80.8%.

Figure 3 shows a preferred embodiment of the apparatus of the invention for pyrolysis and degasification as an example sketch. The wood 10 is added to the pyrolysis reactor 1 via a gas-impermeable carry-in apparatus, a star wheel in the example case illustrated here. The drying and the pyrolysis of the application material takes place by the contact with the hot fluidised-bed material 35 supplied by an overflow from the combustion fluidised bed 3. The produced pyrolysis gas 13 is led into the reaction zone 2 while adding steam 21, said reaction zone being designed by way of example here as a tube heat transfer member. After transformation of the pyrolysis gas 13 with the steam 21, the product gas 23 is cooled and cleaned in the preparation stage 5. To avoid the unwanted exchange of gases between the pyrolysis reactor 1 and the combustion fluidised bed 3, the fan of the product gas line 50 and the fan of the flue gas line 60 must be matched to one another. Due to the fact that the overflow from the combustion fluidised bed 3 to the pyrolysis reactor 1 is designed such that this is constantly filled with fluidised-bed material 35, then in combination with the said fans, the exchange of gas between both reactors is prevented in a simple manner. A

screw is preferably provided to transport the mixture of solid pyrolysis residue and circulating fluidised-bed material 14 into the combustion fluidised bed 3. The screw is to be designed such that the pressure loss through the screw passages filled with material is larger than via the fluidised bed 3 so that the air 31 supplied to the combustion fluidised bed 3 does not flow in the by-pass through the pyrolysis reactor 1. A steam flow 71, which is pressure-relieved for example via a turbine 9, is produced from a water flow with the heat of the flue gas flow 37 via a heat transfer member 8. Part of the steam flow 71 can be used as steam 21 for the reaction zone 2. The waste gas 60 is supplied to a flue gas cleaning 6.

Reference numeral list:

1	pyrolysis reactor
10	application material
11	solidifying agent
12	heat loss
13	pyrolysis gas
14	mixture of solid pyrolysis residue and fluidised-bed material
15	pyrolysis gas
2	reaction zone
21	solidifying agent
22	heat loss
23	product gas
3	firing
31	air
32	fluidised-bed material
33	heat loss
34	heat flow
35	fluidised-bed material
36	heat flow
37	combustion waste gas
4	pre-treatment stage
5	gas cleaning
50	cleaned product gas
6	flue gas cleaning
60	waste gas
7	water treatment
70	water

71 steam
8 heat transfer member
9 turbine

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A method and an apparatus for the pyrolysis and gasification of organic substances or mixtures of organic substances

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Claims

1. A method for the pyrolysis and gasification of organic substances or mixtures of organic substances, wherein

1.1 the organic substances are introduced into a drying and pyrolysis reactor (1) in which the organic substances are brought into contact with the fluidised-bed material (35) of the combustion fluidised bed (3) or in which the organic substances are brought into contact with the fluidised-bed material (35) and the reactor wall of the combustion fluidised bed (3), whereby a drying and pyrolysis take place, in which the organic substances are transformed into steam from the drying and into pyrolysis products (13), wherein the pyrolysis products consist of gases with condensable substances and solid carbonaceous residue;

1.2 the solid carbonaceous residue or the solid carbonaceous residue and portions of the steam and of the pyrolysis gases with condensable substances and the fluidised-bed material are guided back into the combustion fluidised bed (3) in which the carbonaceous residue of the organic substances is incinerated, the fluidised-bed material is heated up and is again guided into the pyrolysis reactor (1);

1.3 the steam from the drying and the pyrolysis gases (13) are subsequently treated with condensable substances in a further reaction zone (2) such that a product gas (23) with a high calorific value is available;

1.4 the drying and pyrolysis are carried out in at least one or more pyrolysis reactors (1);

1.5 the drying and pyrolysis are preferably carried out in two or more pyrolysis reactors (1) which consist of two or more moving bed reactors or of two or more rotary reactors or of rotary reactors and moving bed reactors;

1.6 the combustion fluidised bed (3), in which the pyrolysis residues are incinerated, is operated as a stationary fluidised bed;

1.7 no solidifying agent or, optionally, a solidifying agent such as steam, oxygen or air or a mixture thereof is supplied to the pyrolysis gases (13);

1.8 the pyrolysis gases (13) are led into an indirect heat exchanger (2) in which they optionally react with the solidifying agent (21);

1.9 the firing waste gases (37) or the firing waste gases and the fluidised-bed material of the combustion fluidised bed (3) are brought into contact with the indirect heat exchanger (2) such that their thermal content is used for the reaction of the pyrolysis gases (13) with the solidifying agent (21);

1.10 the fluidised-bed material (3) consists only of the ash of the organic substances, or of the ash and unburned carbonaceous residues of the organic substances, or of the ash of the organic substances and of additional fluidised material, or of the ash and unburned carbonaceous residues of the organic substances and of additional fluidised material.

2. A method in accordance with claim 1, wherein the pyrolysis is carried out at a temperature of 450°C to 750°C.

3. A method in accordance with either of claims 1 or 2, wherein the product gas (23) is guided back into the pyrolysis reactor (1).

4. A method in accordance with any of claims 1 to 3, wherein solidifying agents (21) such as steam, oxygen or air or a mixture thereof are added into the pyrolysis reactor (1).

5. A method in accordance with any of claims 1 to 4, where the surface of the reactor wall of the combustion fluidised bed (3) has any closed geometrical shape on the side of the pyrolysis reactor (1) and the combustion fluidised bed (3).

6. A method in accordance with any of claims 1 to 5, wherein the reactions of the pyrolysis gases (13) with the solidifying agent (21) are carried out at temperatures of 800°C to 1,050°C.

7. A method in accordance with any of claims 1 to 6, wherein the reactions of the pyrolysis gases (13) with the solidifying agent (21) are carried out in the presence of a catalyst.

8. A method in accordance with any of claims 1 to 7, wherein the reactions (13) with the solidifying agent (21) are carried out in a solid bed of catalyst material.

9. A method in accordance with any of claims 1 to 8, wherein the reactions of the pyrolysis gases (13) with the solidifying agent (21) are carried out in a fluidised bed of catalyst material.

10. A method in accordance with any of claims 1 to 9, wherein the reactions of the pyrolysis gases (13) with the solidifying agent (21) are supplied in the presence of a catalyst added to the pyrolysis gas (13) in the entrained flow.

11. An apparatus for the carrying out of a method for the pyrolysis and gasification of organic substances or mixtures of organic substances, in particular for the carrying out of a method in accordance with one or more of claims 1 to 10, comprising a pyrolysis reactor (1), a fluidised-bed firing (3) for the pyrolysis residue, a reaction zone (2) for the pyrolysis gases (13), and a fluidised-bed material circulation between the combustion fluidised bed (3) and the pyrolysis reactor 1),

characterised in that

a shaft reactor or a rotary reactor having a sluice for the application material and an inlet for the fluidised-bed material from the combustion fluidised bed (3) is disposed next to the combustion fluidised bed; in that the shaft reactor (1) has a transport apparatus into the combustion fluidised bed at its lower end ; in that the combustion fluidised bed (3) has an overflow for transferring the fluidised-bed material into the shaft reactor (1); and in that the waste gases (37) of the combustion fluidised bed (3) can be supplied to a heat transfer member (2) which is connected to the shaft reactor (1) for the pyrolysis gases (13).

12. An apparatus in accordance with claim 11, wherein fluidised-bed material can be removed from the combustion fluidised bed (3) at least at one point or at a plurality of points and can be guided into the pyrolysis sector.

13. An apparatus in accordance with either of claims 11 or 12, wherein fluidised-bed material can be removed from the combustion fluidised bed (3) at least at one point or at a plurality of points by means of one or more overflows and can be guided into the pyrolysis reactor.

14. An apparatus in accordance with any of claims 10 to 13, wherein refractory substances can be added to form a fluidised bed.

15. An apparatus in accordance with any of claims 10 to 14, wherein the components of the application material which cannot be burned and which cannot be gasified can be used to form a fluidised bed.

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A method and an apparatus for the pyrolysis and gasification of organic substances or mixtures of organic substances

Abstract

A method serves for the pyrolysis and gasification of organic substances or mixtures of organic substances. The organic substances are introduced into a drying and pyrolysis reactor (1) in which they are brought into contact with the fluidised-bed material (35) of the combustion fluidised bed (3) or in which they are brought into contact with the fluidised-bed material (35) and the reactor wall of the combustion fluidised bed (3), whereby a drying and pyrolysis take place. The solid carbonaceous residue, optionally with portions of the steam and of the pyrolysis gases, and the fluidised-bed material are guided back into the combustion fluidised bed (3) in which the carbonaceous residue of the organic substances is incinerated, the fluidised-bed material is heated up and is again guided into the pyrolysis reactor (1). The steam from the drying and the pyrolysis gases (13) are subsequently treated with condensable substances in a further reaction zone (2) such that a product gas (23) with a high calorific value is available. The drying and pyrolysis are carried out in at least

one or more pyrolysis reactors (1). The combustion fluidised bed (3), in which the pyrolysis residues are incinerated, is operated as a stationary fluidised bed. The pyrolysis gases (13) are led into an indirect heat exchanger. The firing waste gases (37), optionally with the fluidised-bed material of the combustion fluidised bed (3), are brought into contact with the indirect heat exchanger (2) such that their thermal content is used for the reaction of the pyrolysis gases (13) with the solidifying agent (21).

(12) NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES PATENTWESENS (PCT) VERÖFFENTLICHTE INTERNATIONALE ANMELDUNG

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[Fortsetzung auf der nächsten Seite]

(54) Title: METHOD AND DEVICE FOR PYROLYZING AND GASIFYING ORGANIC SUBSTANCES OR SUBSTANCE MIXTURES

(54) Bezeichnung: VERFAHREN UND VORRICHTUNG ZUR PYROLYSE UND VERGASUNG VON ORGANISCHEN STOFFEN ODER STOFFGEMISCHEN

(57) Abstract: The invention relates to a method for pyrolyzing and gasifying organic substances or substance mixtures. The organic substances are introduced into a drying and pyrolysis reactor (1) in which they are brought into contact with the fluidized bed material (35) of the combustion fluidized bed (3) or in which they are brought into contact with the fluidized bed material (35) and the reactor wall of the combustion fluidized bed (3), whereby a drying and a pyrolysis occurs. The fluidized bed material and the solid residue which contains carbon are fed, optionally with portions of the water vapor and of the pyrolysis gases, back into the combustion fluidized bed (3) in which the residue of the organic substances which contains carbon is combusted, the fluidized bed material is heated and is fed once again into the pyrolysis reactor (1). The water vapor resulting from the drying, and the pyrolysis gases (13) are subsequently treated with condensable substances in another reaction zone (2) so that a product gas (23) having a high thermal value is produced. The drying and the pyrolysis are carried out in at least one or more pyrolysis reactors (1). The combustion fluidized bed (3) in which the pyrolysis residues are combusted is operated as a stationary fluidized bed. The pyrolysis gases (13) are led into an indirect heat exchanger. The firing waste gases (37) are, optionally with the fluidized bed material of the combustion fluidized bed (3), brought into contact with the indirect heat exchanger (2) in such a manner that the heat content thereof is used for reacting the pyrolysis gases (13) with the reaction agent (21).

(57) Zusammenfassung: Ein Verfahren dient zur Pyrolyse und Vergasung von organischen Stoffen oder Stoffgemischen. Die organischen Stoffe werden in einen Trocknungs- und Pyrolysereaktor (1) eingebracht, in dem sie mit dem Wirbelbettmaterial (35) der Verbrennungswirbelschicht (3) in Kontakt gebracht werden oder in dem sie mit dem Wirbelbettmaterial (35) und der Reaktorwandung der Verbrennungswirbelschicht (3) in Kontakt gebracht werden, wodurch eine Trocknung und Pyrolyse stattfindet. Der feste kohlenstoffhaltige Rückstand, gegebenenfalls mit Anteilen des Wasserdampfs und der Pyrolysegase, und das Wirbelbettmaterial werden zurück in die Verbrennungswirbelschicht (3) geführt, in der der kohlenstoffhaltige Rückstand der organischen Stoffe verbrannt, das Wirbelbettmaterial aufgeheizt und wieder in den Pyrolysereaktor (1) geführt wird. Der Wasserdampf aus der Trocknung und die Pyrolysegase (13) werden mit kondensierbaren Substanzen in einer weiteren Reaktionszone (2) derart nachbehandelt, daß ein Produktgas (23) mit hohem Heizwert zur Verfügung steht. Die Trocknung und Pyrolyse werden in mindestens einem oder mehreren Pyrolysereaktoren (1) durchgeführt. Die Verbrennungswirbelschicht (3), in der die Pyrolyserückstände verbrannt werden, wird als stationäre Wirbelschicht betrieben. Die Pyrolysegase (13) werden in einen indirekten Wärmetauscher geleitet. Die Feuerungsabgase (37) werden, gegebenenfalls mit dem Wirbelbettmaterial der Verbrennungswirbelschicht (3), so mit dem indirekten Wärmetauscher (2) in Kontakt gebracht, daß deren Wärmeinhalt für die Reaktion der Pyrolysegase (13) mit dem Reaktionsmittel (21) genutzt wird.

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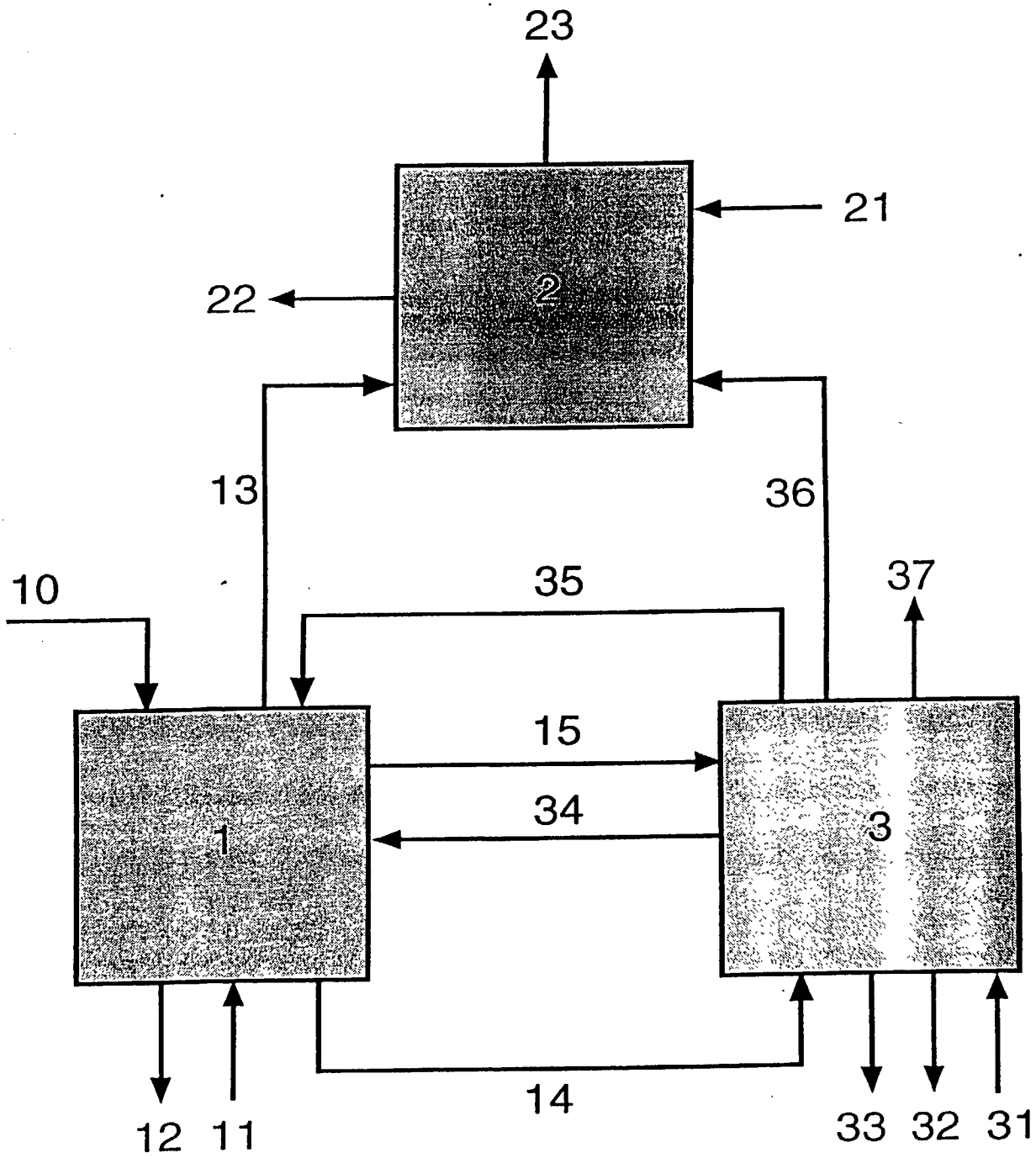

Fig. 1

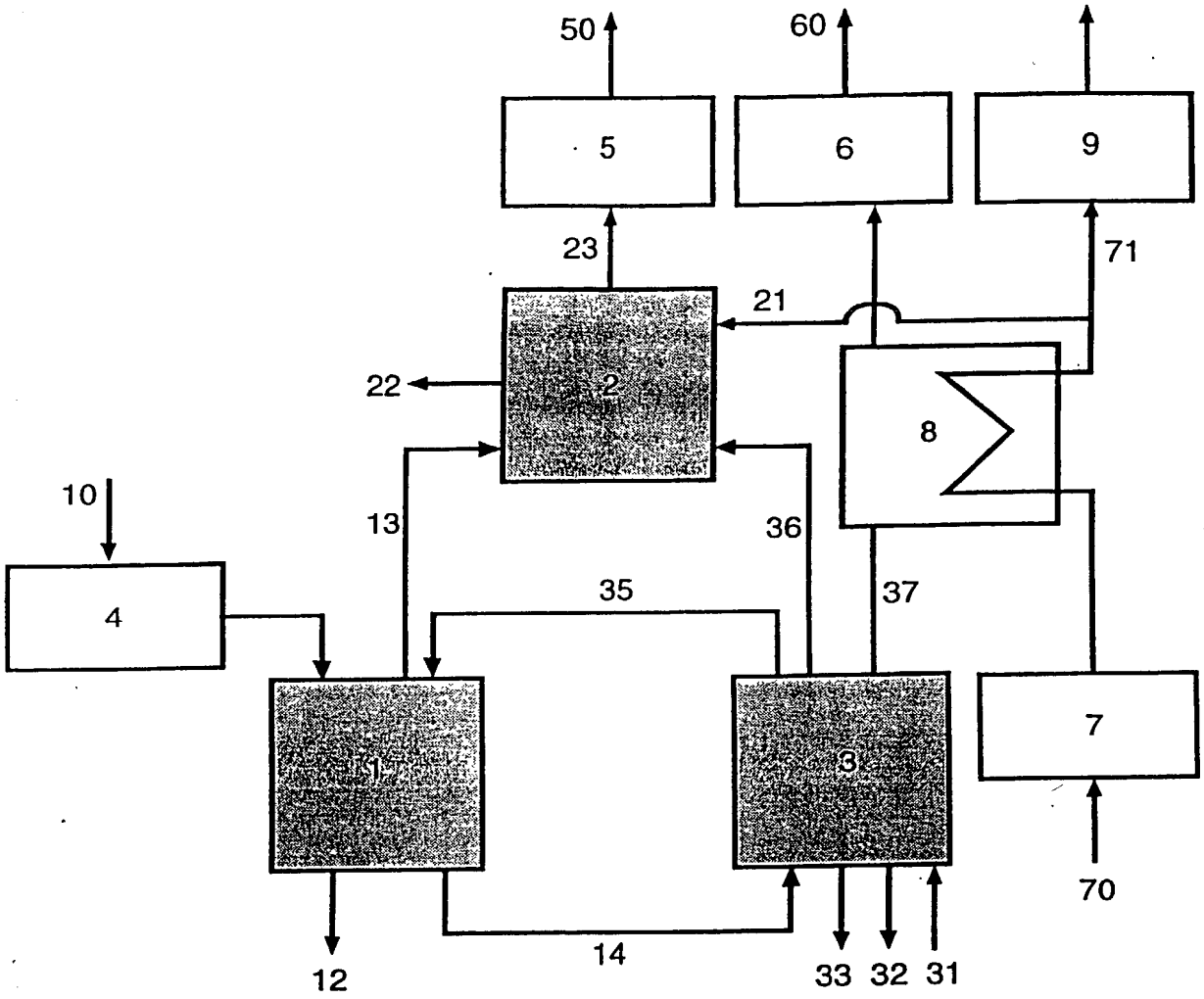

Fig. 2

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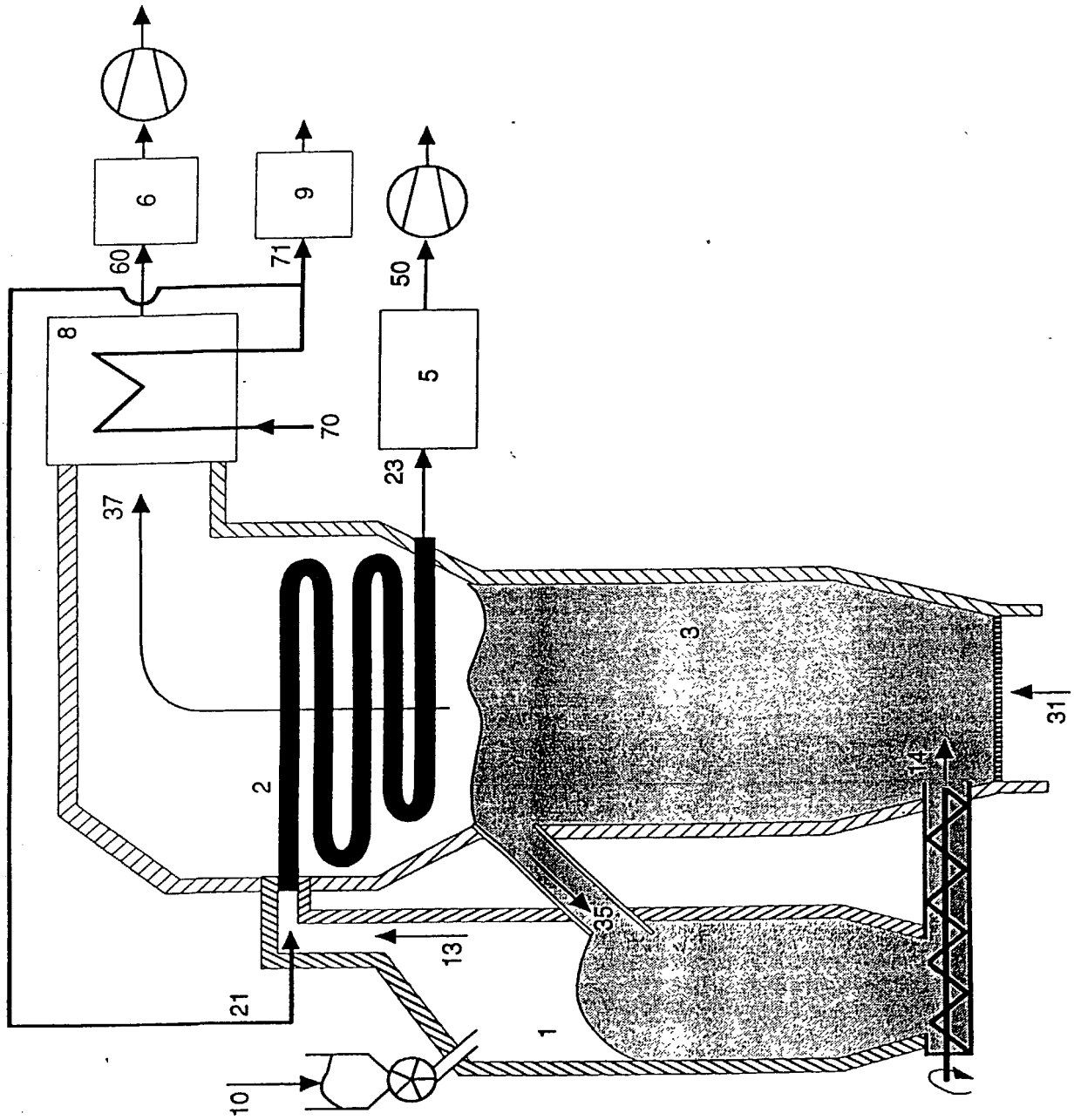

Fig. 3

POWER OF ATTORNEY

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DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

SIGNATURE(S)

NOTE: Carefully indicate the family (or last) name as it should appear on the filing receipt and all other documents.

100

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200

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NOTE: Where item (c) is entered above and the International Application which designated the U.S. itself claimed priority check item (e), enter the details below and make the priority claim.

PRIOR FOREIGN/PCT APPLICATION(S) FILED WITHIN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO THIS APPLICATION AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. §119(a)-(d)

COUNTRY (OR INDICATE IF PCT)	APPLICATION NUMBER	DATE OF FILING *(day, month, year)*	PRIORITY CLAIMED UNDER 35 U.S.C. 119
Germany	199 30 071.2	30, 06, 99	☒ YES ☐ NO
			☐ YES ☐ NO

CLAIM FOR BENEFIT OF PRIOR U.S. PROVISIONAL APPLICATION(S) (34 U.S.C. §119(e))

I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below:

PROVISIONAL APPLICATION NUMBER **FILING DATE**

_____ _____

ALL FOREIGN APPLICATION(S), IF ANY FILED MORE THAN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO THIS U.S. APPLICATION

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NOTE: If the application filed more than 12 months from the filing date of this application is a PCT filing forming the basis for this application entering the United States as (1) the national stage, or (2) a continuation, divisional, or continuation-in-part, then also complete ADDED PAGES TO COMBINED DECLARATION AND POWER OF ATTORNEY FOR DIVISIONAL, CONTINUATION OR CIP APPLICATION for benefit of the prior U.S. or PCT application(s) under 35 U.S.C. §120.

SPECIFICATION IDENTIFICATION

the specification of which: *(complete (a), (b) or (c))*

(a) ☐ is attached hereto.

(b) ☐ was filed on_____ as ☐ Serial No.or ☐_____ Express Mail No. , as Serial No. not yet known _____ and was amended on _____ *(if applicable)*.

NOTE: Amendments filed after the original papers are deposited with the PTO which contain new matter are not accorded a filing date by being referred to in the declaration. Accordingly, the amendments involved are those filed with the application papers or, in the case of a supplemental declaration, are those amendments claiming matter not encompassed in the original statement of invention or claims. See 37 C.F.R. 1.67.

(c) ☒ was described and claimed in PCT International Application No. PCT/EP00/05953 filed on June 27, 2000 and as amended under PCT Article 19 on _____ *(if any)*.

ACKNOWLEDGMENT OF REVIEW OF PAPERS AND DUTY OF CANDOR

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 C.F.R. §1.56, and

☐ in compliance with this duty there is attached an information disclosure statement in accordance with 37 C.F.R. 1.98.

PRIORITY CLAIM (35 U.S.C. §119)(a)-(d)

I hereby claim foreign priority benefits under Title 35, United States Code, §119(a)-(d) of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

(complete (d) or (e))

(d) ☐ no such applications have been filed.

(e) ☒ such applications have been filed as follows.

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☐ Signature for subsequent joint inventors.
Number of pages added _____.

☐ Signature by administrator(trix), executor(trix) or legal representative for deceased or incapacitated inventor.
Number of pages added _____.

☐ Signature for inventor who refuses to sign or cannot be reached by person authorized under 37 C.F.R. §1.47.
Number of pages added _____.

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☐ Added pages to combined declaration and power of attorney for divisional, continuation, or continuation-in-part (CIP) application.
Number of pages added 1.

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